MP MATERIALS PERFORMANCE
CORROSION PREVENTION AND CONTROL WORLDWIDE

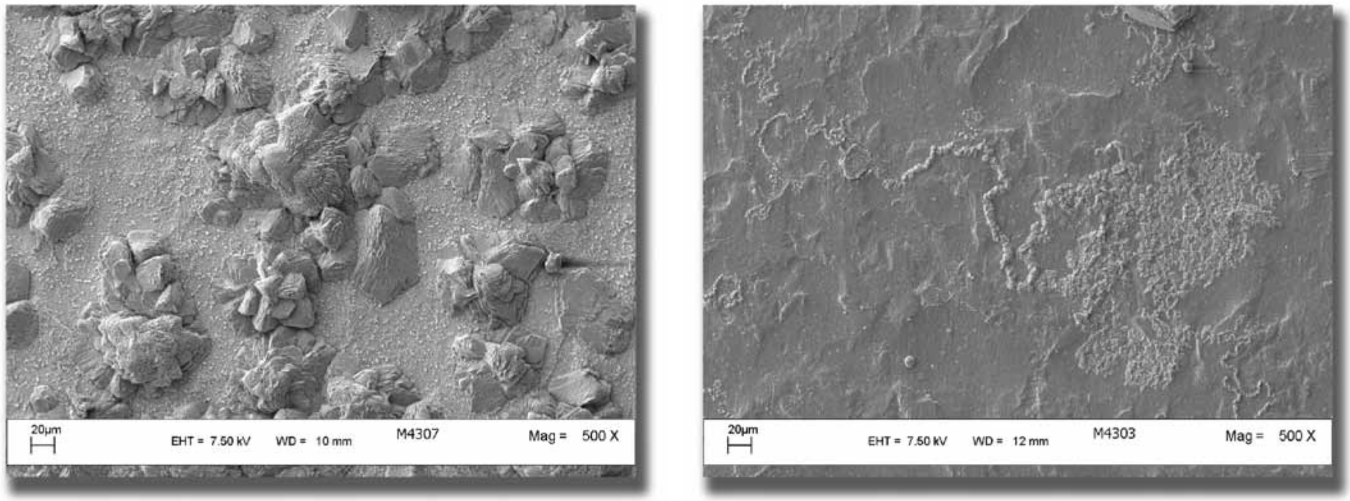
Unique inhibitor prevents both corrosion and scaling in industrial cooling water

Chemists with BWA Water Additives (Manchester, United Kingdom), a provider of specialty water solutions for industrial water treatment, recently developed a new phosphono polymer-based organic corrosion inhibitor for industrial water systems that displays effective corrosion inhibition as well as scale control for ferrous metals in water across a broader range of pH values and hardness levels. According to NACE International member Darrell Hartwick, technology and industrial water marketing director for BWA Water Additives, this next-generation organic inhibitor technology bridges the gap between established corrosion and scale inhibitor technology by exhibiting both the corrosion prevention properties of hydroxyphosphono acetic acid (HPA) chemistry and the anti-scalant properties of phosphonocarboxylate acid (POCA) chemistry, both developed by BWA Water Additives.

Soft or hard water typically is defined by the amount of calcium and magnesium in the water, Hartwick explains. Calcium levels are generally <50 ppm in soft water, between 50 to 300 ppm in medium hard water, and >300 ppm in hard water, he adds. The new inhibitor technology, based on enhanced phosphonocarboxylate (EPOC) chemistry, works well in soft or medium hard water because the EPOC reacts with the calcium in cooling water and mediates the formation of a very thin, protective film of calcium carbonate ($CaCO_3$) and calcium-EPOC, which is only a few molecules thick, on the surface of metal components. This film isolates the metal from the cooling water and prevents oxygen in the water from oxidizing the underlying metal and corroding it. Because the film formation is very uniform and complete, it protects the metal surface from pitting corrosion as well as general corrosion attack. Hartwick explains that the film formed on the metal surface by the inhibitor is dynamic and is continuously being formed and dissolved as water passes through the cooling system. Maintaining uniform film coverage on the metal is dependent on having a consistent level of the inhibitor in the cooling water to replenish the film and plug any holidays in the inhibitor film as it changes.

Kim Bartlett, lab technician, collects deposit samples for analysis in BWA Water Additives' Atlanta, Georgia research and development facility. Photo courtesy of BWA Water Additives.

While a microscopically thin film can be an effective corrosion inhibitor and works well in the cooling process, a thicker calcium film, or scale (~2-mm thick or more), can interfere with heat transfer and adversely affect the system. As the level of calcium and alkalinity in the cooling water increases, there is a greater potential for scale to form. Generally, a corrosion inhibitor that readily precipitates with calcium to form a protective film is not very effective at stabilizing calcium in the bulk water and would not make an effective scale inhibitor. Conversely, an effective scale inhibitor will stabilize calcium in the bulk water rather than react with it to form a barrier film. The challenge with developing this new corrosion inhibitor chemistry was to strike a balance between the interaction with calcium to form a thin film for effective corrosion inhibition and, at the same time, sufficient maintenance of calcium tolerance (solubility) to prevent scale



A 500X magnified image (left) of a mild steel coupon exposed to 100 mg/L HPA shows the thin film formation on the metal surface due to interaction of calcium with the HPA. A 500X magnified image (right) of a mild steel coupon exposed to 100 mg/L EPOC illustrates a more uniform and consistent EPOC-calcium inhibitor film on the metal surface. Images courtesy of BWA Water Additives.

formation, especially in hard water with high alkalinity, says Hartwick.

The new EPOC inhibitor is engineered to react with calcium only to the point where a microscopic protective film is formed. This is due to EPOC's higher calcium ion tolerance, which enables EPOC to precipitate in a very controlled manner with calcium in cooling waters with elevated calcium and alkalinity levels, Hartwick notes. The resulting barrier film is uniformly deposited and thoroughly covers the metal surface. When tested for corrosion inhibition, EPOC demonstrated the ability to easily form a microscopic inhibiting film in water containing calcium ion concentrations of 150 and 300 mg/L, with measured corrosion rates of 0.0375 mm/y or less using 10 to 30 mg/L of the inhibitor. In a scale inhibition test, EPOC demonstrated 100% scale inhibition in water with 375 mg/L of calcium as $CaCO_3$ using 4 mg/L of the inhibitor. "This inhibitor works well with higher calcium levels and higher alkalinity, and allows us to broaden the range of water chemistries than can be protected by providing acceptable levels of corrosion and scale inhibition," says Hartwick.

Because EPOC is all organic and has a lower phosphorous content that other phosphonates, it has less potential to impact the environment in the same way as inorganic inhibitors; and performance test results meet or surpass the corrosion inhibition benchmarks previously established by inorganic, heavy metal inhibitors, says Paul Turgeon, president of BWA Water Additives. Its dual inhibition properties can provide both corrosion and scale control in one additive. He notes that EPOC can be used in open recirculating or closed water systems in all industries that rely on cooling water for heat transfer.

Additional information on research and test results for EPOC can be found in the paper, "A New Multi-functional Corrosion and Scale Inhibitor," by David Wilson, CORROSION 2008 paper no. 08077, presented in New Orleans, Louisiana.

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